



EBAF Edition 4.1

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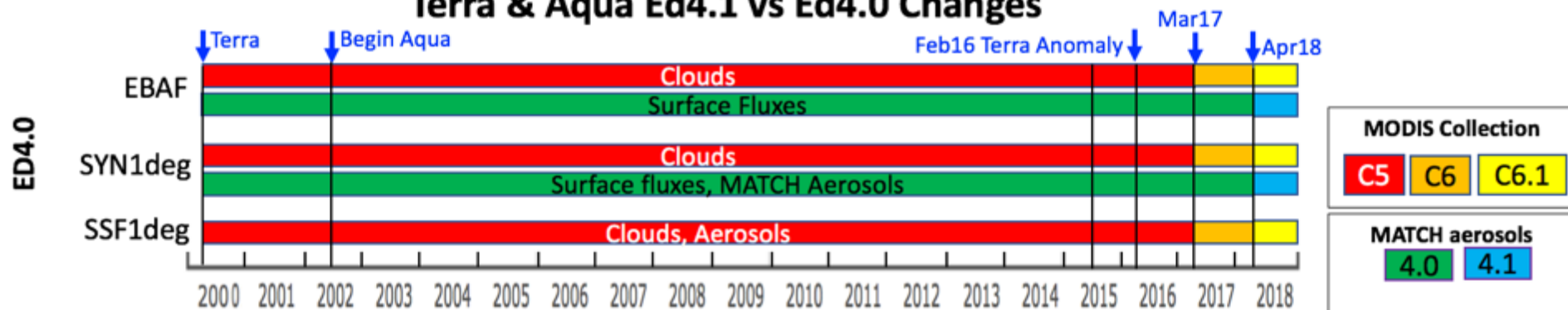


CERES Science Team Meeting, October 29-31, 2019
Lawrence Berkeley National Laboratory, Berkeley, CA

Terra & Aqua Edition 4.0

- The CERES Terra & Aqua Edition 4.0 processing uses MODIS radiances and aerosols as key inputs.
- CERES Edition 4.0 started with MODIS Collection 5. However, C5 processing at GSFC was terminated at data date February 2017 and superseded with MODIS Collection 6.
- MODIS C6 has been superseded with MODIS Collection 6.1.
- MODIS Collection 6.1 is a major calibration upgrade for select Terra (6.72 and 8.6 μm) and Aqua (visible) channels.
 - Significantly improves the quality of the MODIS cloud mask, especially for Terra

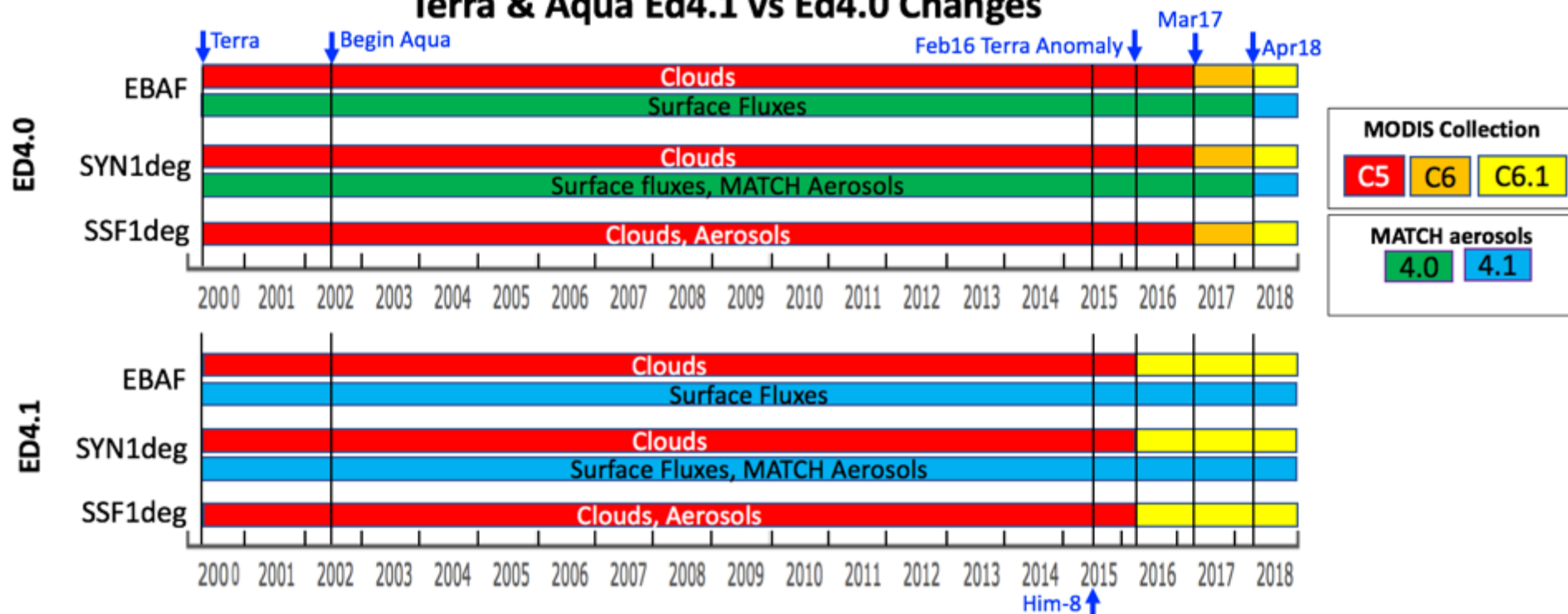
Terra & Aqua Ed4.1 vs Ed4.0 Changes



Terra & Aqua Edition 4.1

- CERES Team has reprocessed Level 2 SSF and all downstream Level 3 products with MODIS C6.1 starting in March 2016, when the MODIS Terra water vapor channel showed a large spurious loss of sensitivity.
- In addition, CERES SYN1deg and EBAF SFC fluxes were reprocessed for the entire CERES record because of a large discontinuity in aerosol optical depths between MODIS C5 and C6.1. AODs are assimilated in MATCH and used to compute surface fluxes.
- EBAF all-sky TOA fluxes remain unchanged between Ed4.0 and Ed4.1.
- Introducing new clear-sky fluxes in EBAF Ed4.1. Definition is more in line with that used in climate models.
- CERES data for 03/2000-02/2016 will not be reprocessed until Ed 5.

Terra & Aqua Ed4.1 vs Ed4.0 Changes



Parameter	ED4.0	ED4.1
MODIS-collection	Terra-MODIS 6.7, 8.6 μm striping, March 2016 to March 2018	MODIS C6.1 resolved the Terra-MODIS 6.7, 8.6 μm striping
MATCH-Edition	Large discontinuity between MODIS C5 & C6.1 AOD inputs	Uses MODIS C6.1 AODs as input for entire CERES record
MODIS Clouds	Impacted Terra cloud properties	Terra cloud properties corrected beginning in Feb 2016
GEO Clouds	Him-8, GOES-16,17, Met-8,11 cloud codes with bugs	Consistent cloud code using MATCH Ed4.1, begin July 2015
Surface fluxes	The clear-sky SW down surface flux was impacted by MODIS C5 & C6.1 AOD discontinuity	SYN surface fluxes, computed using consistent GEO cloud code with MATCH Ed4.1 and tuned fluxes to correct GEO TOA flux

Summary of Changes in EBAF Ed4.1

- 1) Introducing new clear-sky fluxes & associated CREs
- 2) Entire surface flux record reprocessed using consistent aerosols (C6.1) throughout
- 3) Reprocessed cloud properties from 03/2016 onwards (C6.1)

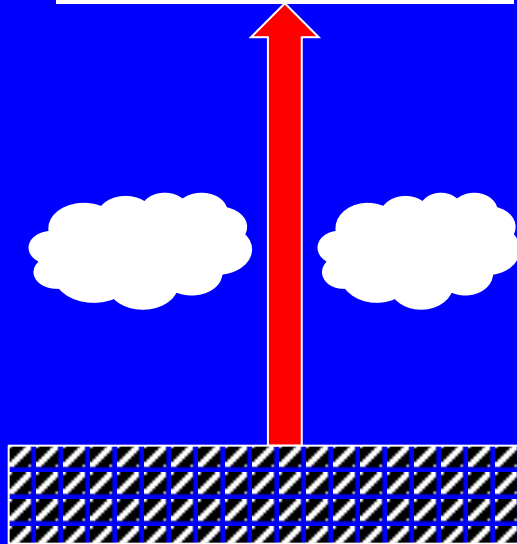
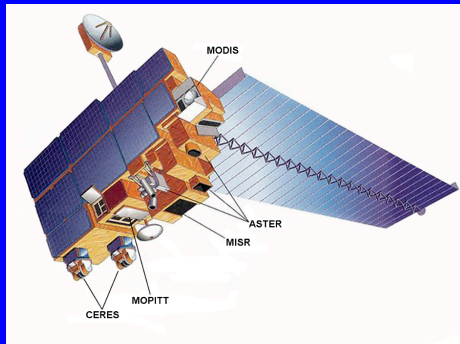
Note: No change to TOA fluxes

“Clear-Sky” Definitions in Models & Observations

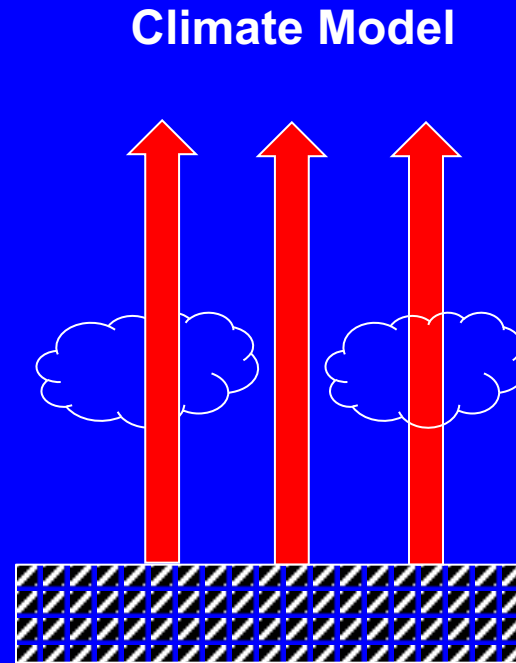
Historical Name	Source	Description	Symbol
Method 1 (Potter et al., 1992)	Observation	Observed clear-sky flux for cloud-free regions within gridbox	F_{cs}^O
Method 1b (Potter et al., 1992)	Model	Model clear-sky flux over gridbox weighted by model clear-sky fraction	$F_{cs}^M (ModWgt)$
Method 1c	Hybrid	Calculated clear-sky flux over gridbox weighted by observed clear-sky fraction	$F_{cs}^C (ObsWgt)$
Method 2	Model	Model or calculated clear-sky flux over gridbox determined by ignoring clouds in the atmospheric column	$F_{cs}^M (CldRem)$ $F_{cs}^C (CldRem)$

- Most model evaluation is between Method 2 (Model) & Method 1 (CERES)

“Clear-Sky” in Models & Observations



Method 1
(Observation)



Method 2
(Climate Models)

- Cloudy columns generally moister than clear columns => Impact on OLR comparisons
- AODs typically larger in cloudy columns => Impact on SW comparisons

New EBAF Ed4.1 Clear-Sky Flux

- We derive an adjustment (Δ^C) to the EBAF observed monthly mean clear-sky flux that enables direct comparisons with model clear-sky fluxes determined by ignoring (“removing”) clouds:

$$F_{CS}^o(CldRem) = F_{CS}^o + \Delta^C$$

$$\Delta^C = F_{CS}^C(CldRem) - F_{CS}^C(ObsWgt)$$

F_{CS}^o = Observed clear-sky flux for cloud-free regions within gridbox (original EBAF)

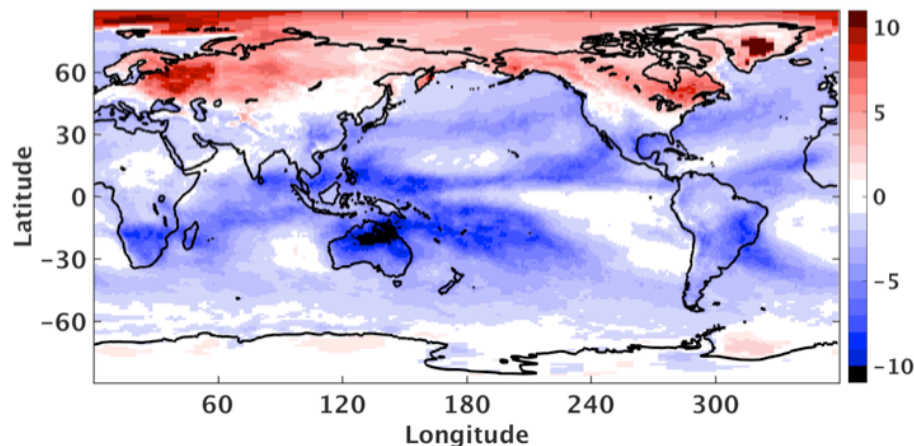
$F_{CS}^C(CldRem)$ = Computed clear-sky flux over entire gridbox determined by ignoring clouds in the atmospheric column (from CERES SYN1deg product)

$F_{CS}^C(ObsWgt)$ = Computed clear-sky flux over entire gridbox weighted by MODIS clear-sky fraction (analogous to F_{CS}^o).

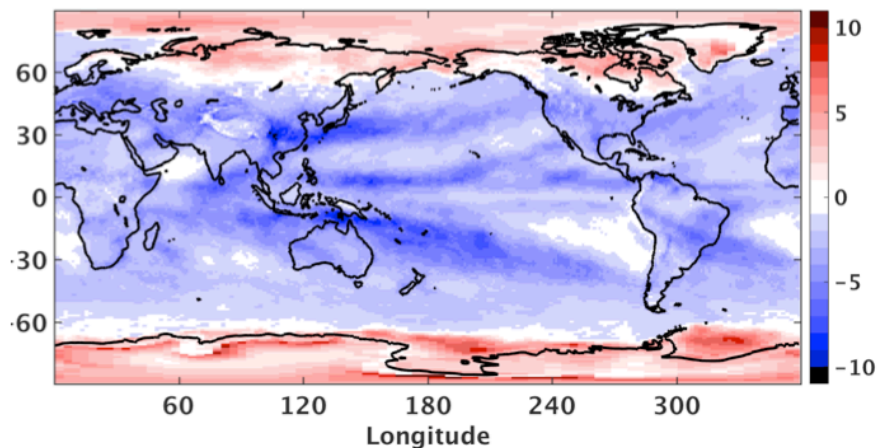
TOA LW Adjustment Factor (Δ^C)

(Climatological Monthly Mean for 07/2005-06/2015; Units: Wm^{-2})

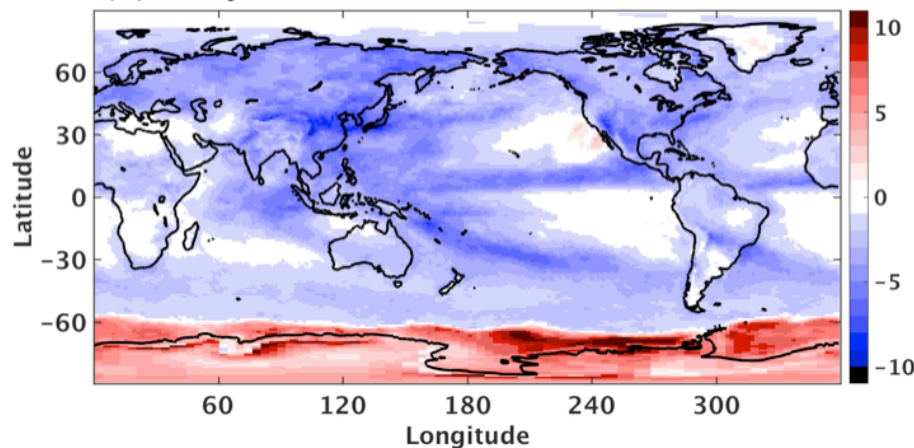
(a) January



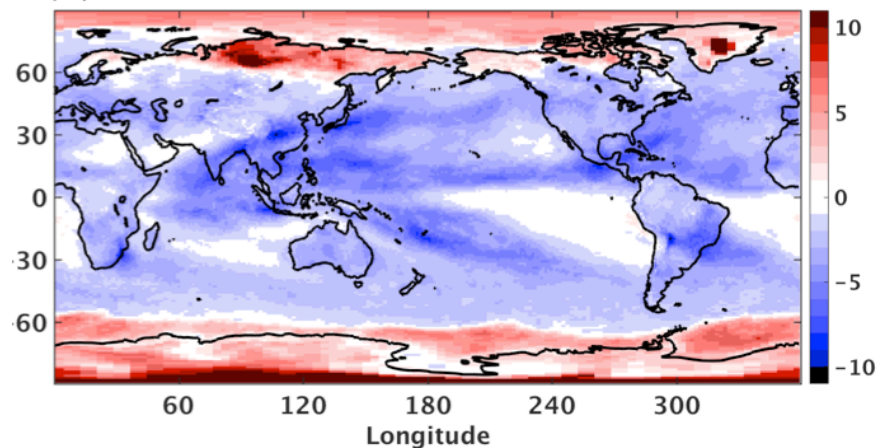
(b) April



(c) July



(d) October

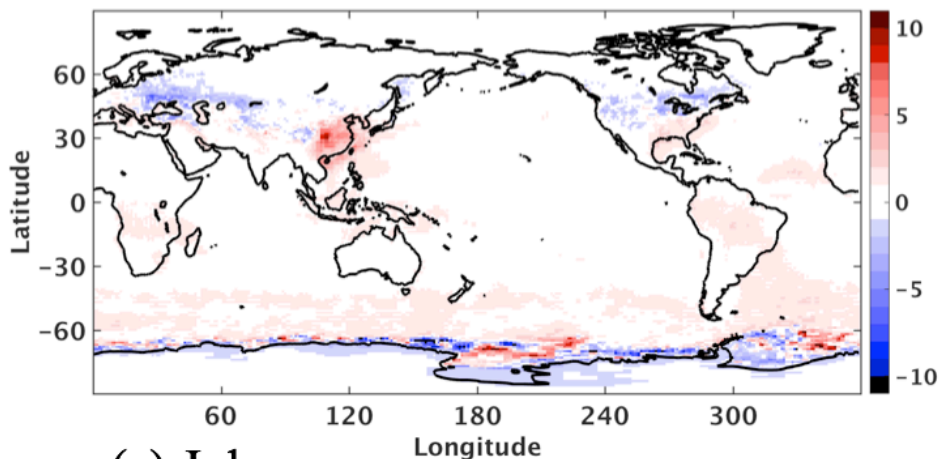


- The overall global mean LW Δ^C for the entire 07/2005-06/2015 period is -2.2 Wm^{-2}

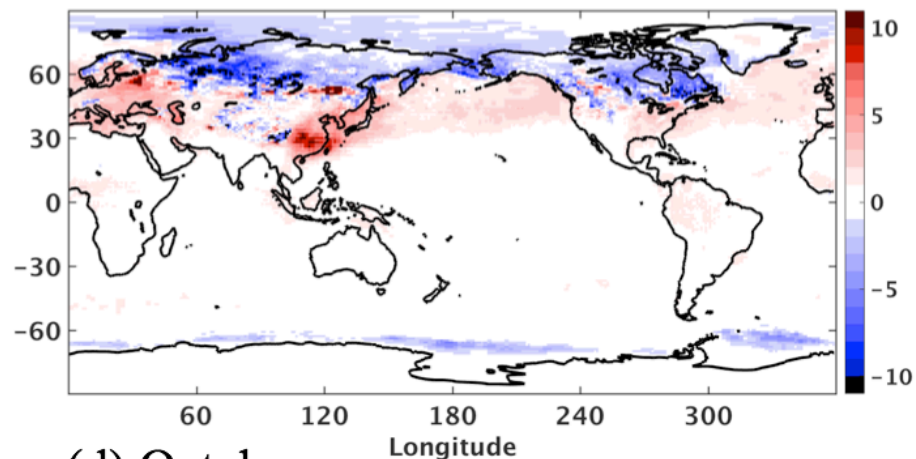
TOA SW Adjustment Factor (Δ^C)

(Climatological Monthly Mean for 07/2005-06/2015; Units: Wm^{-2})

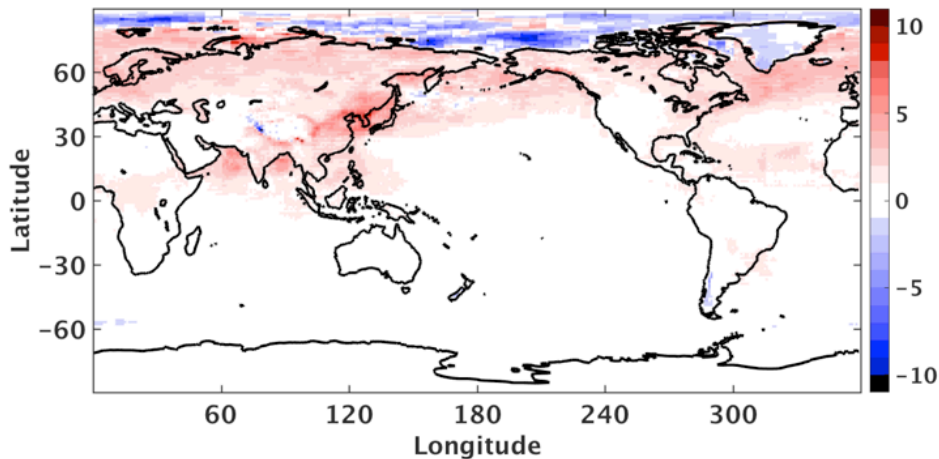
(a) January



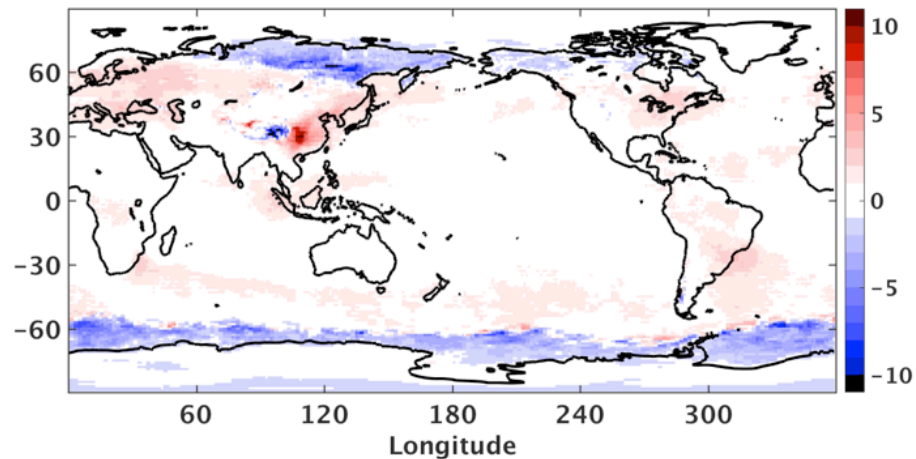
(b) April



(c) July

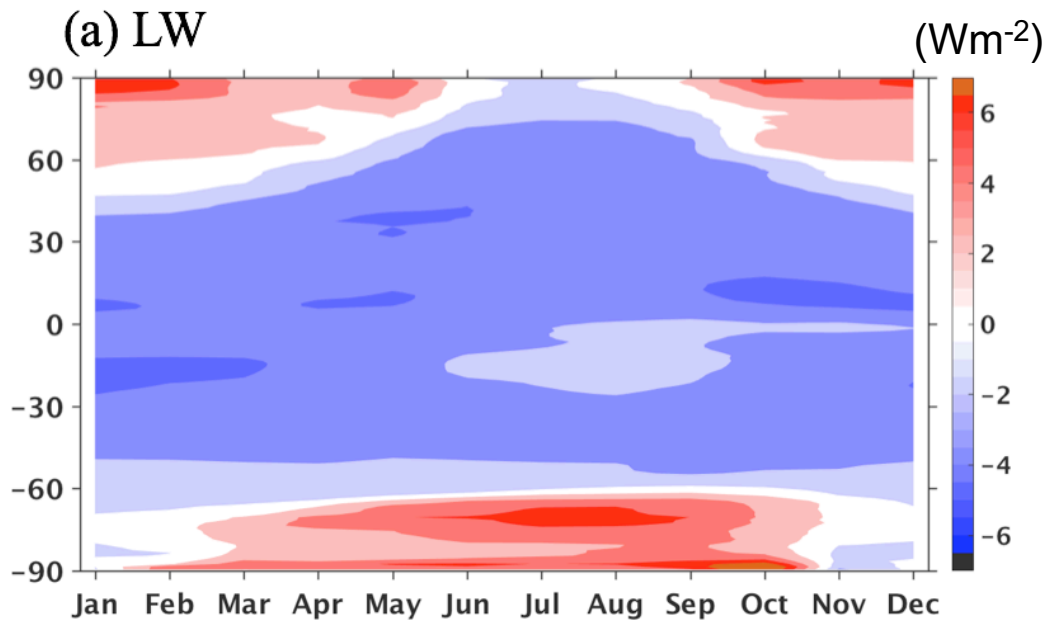


(d) October



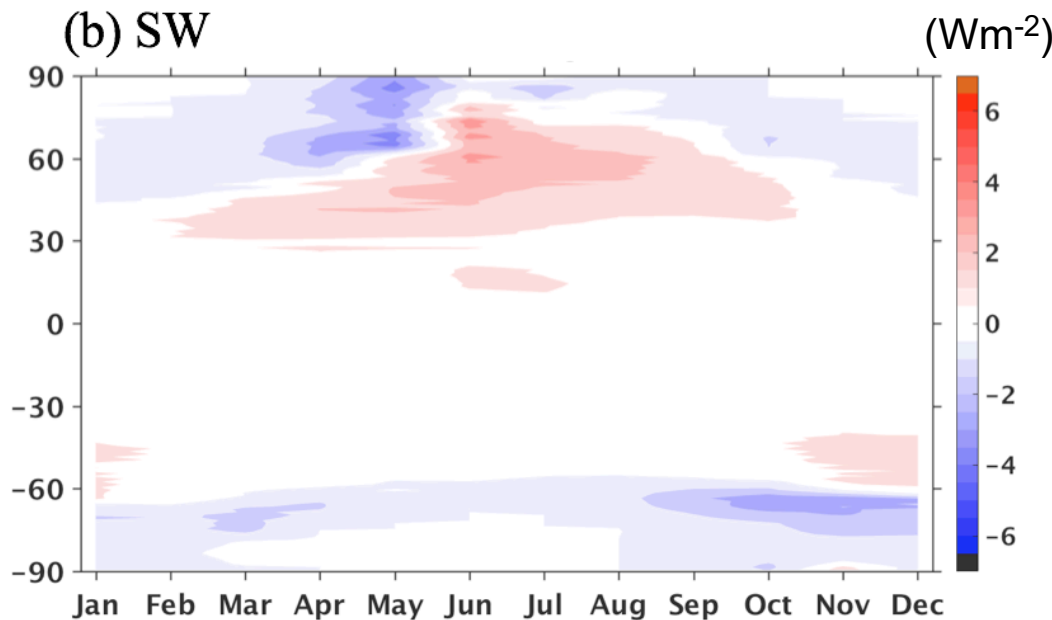
- The overall global mean SW Δ^C for the entire 07/2005-06/2015 period is 0.5 Wm^{-2}

Hovmoller Plots of Climatological Monthly Zonal Mean



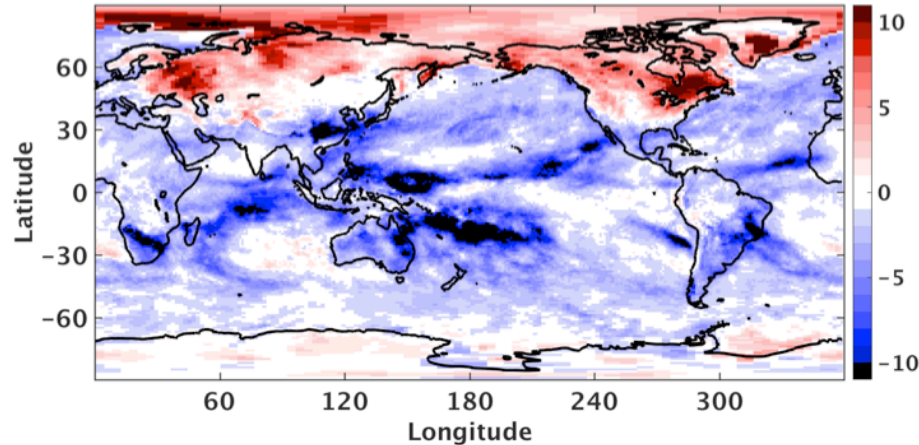
- LW Δ^C is positive during winter at high latitudes because surface and boundary layer temps are warmer in cloudy conditions.

$$\Rightarrow F_{CS}^C(CldRem) > F_{CS}^C(ObsWgt)$$

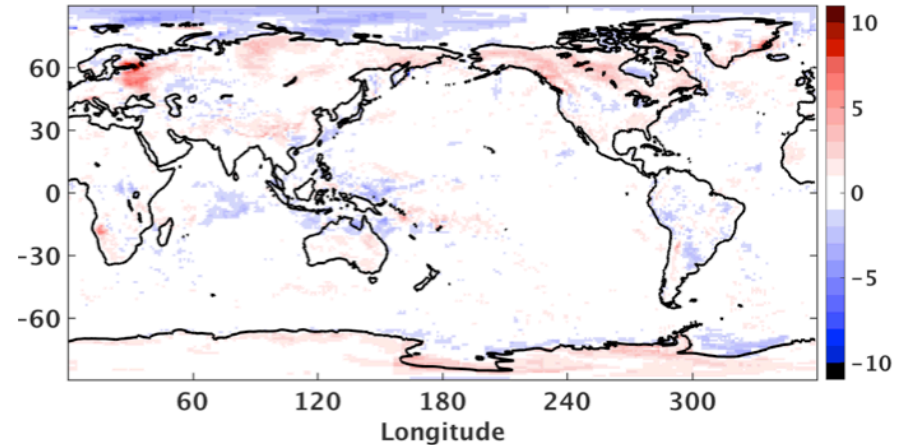


SYN1deg LW Δ^c vs MERRA-2, ERA-Interim and ERA5 (January 2008; For same MODIS-observed clear-sky weights)

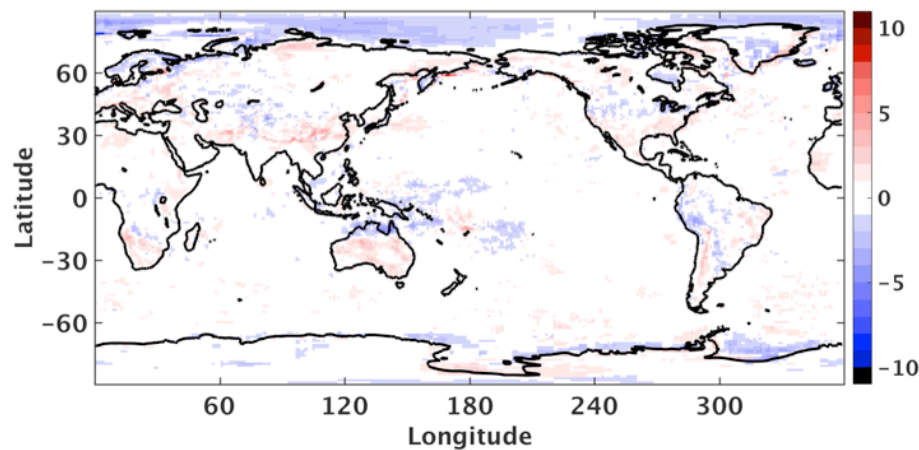
(a) $\Delta^c(\text{SYN1deg})$ (Wm^{-2})



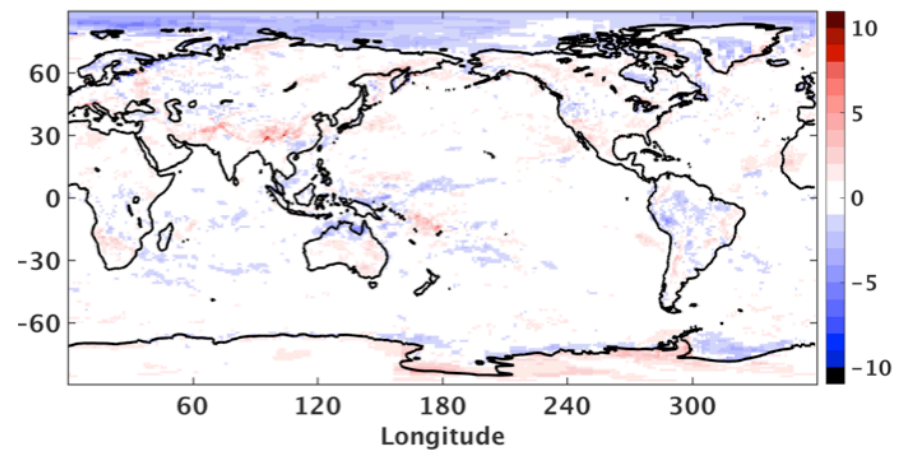
(b) $\Delta^c(\text{MERRA-2}) - \Delta^c(\text{SYN1deg})$ (Wm^{-2})



(c) $\Delta^c(\text{ERA-Interim}) - \Delta^c(\text{SYN1deg})$ (Wm^{-2})



(d) $\Delta^c(\text{ERA5}) - \Delta^c(\text{SYN1deg})$ (Wm^{-2})

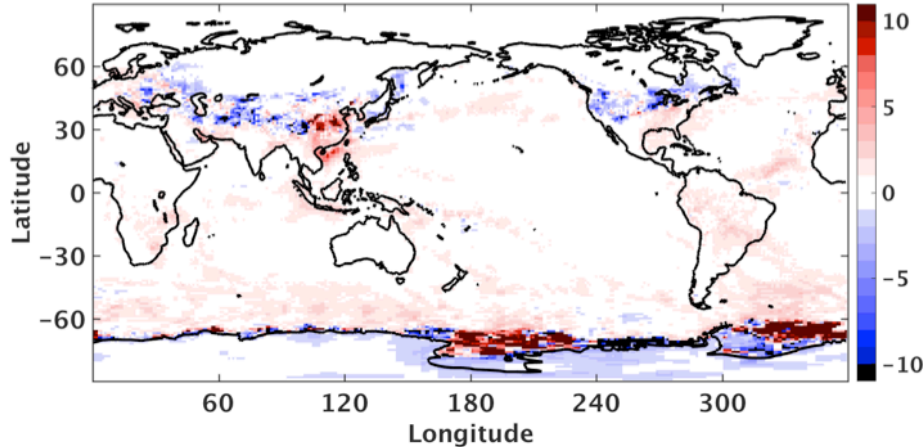


- Regional RMS difference $< 1 \text{ Wm}^{-2}$.

SYN1deg SW Δ^c vs MERRA-2, ERA-Interim and ERA5 (January 2008; For same MODIS-observed clear-sky weights)

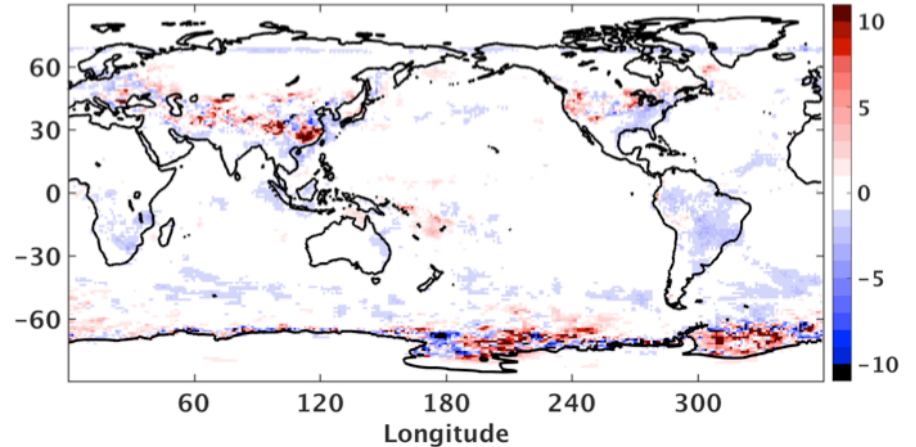
(a) $\Delta^c(\text{SYN1deg})$

(Wm^{-2})



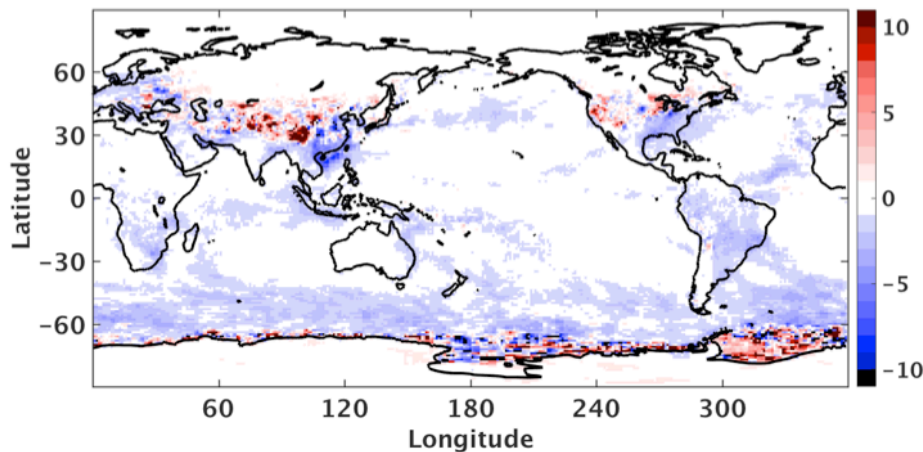
(b) $\Delta^c(\text{MERRA-2}) - \Delta^c(\text{SYN1deg})$

(Wm^{-2})



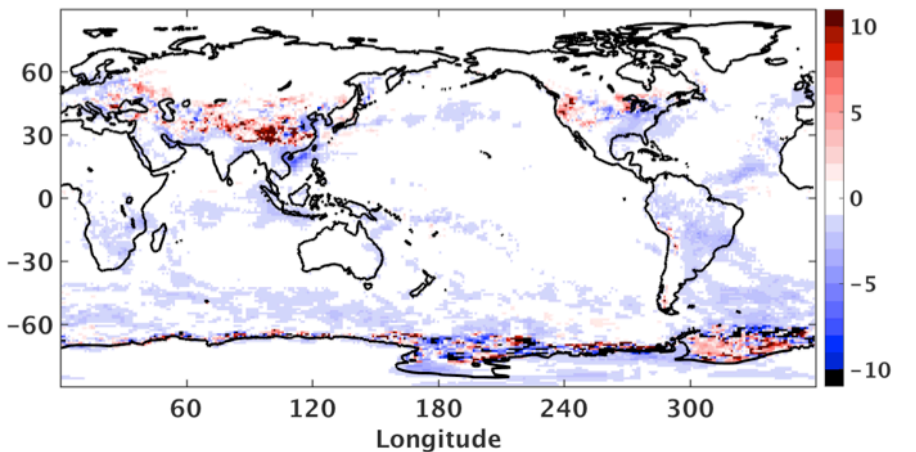
(c) $\Delta^c(\text{ERA-Interim}) - \Delta^c(\text{SYN1deg})$

(Wm^{-2})



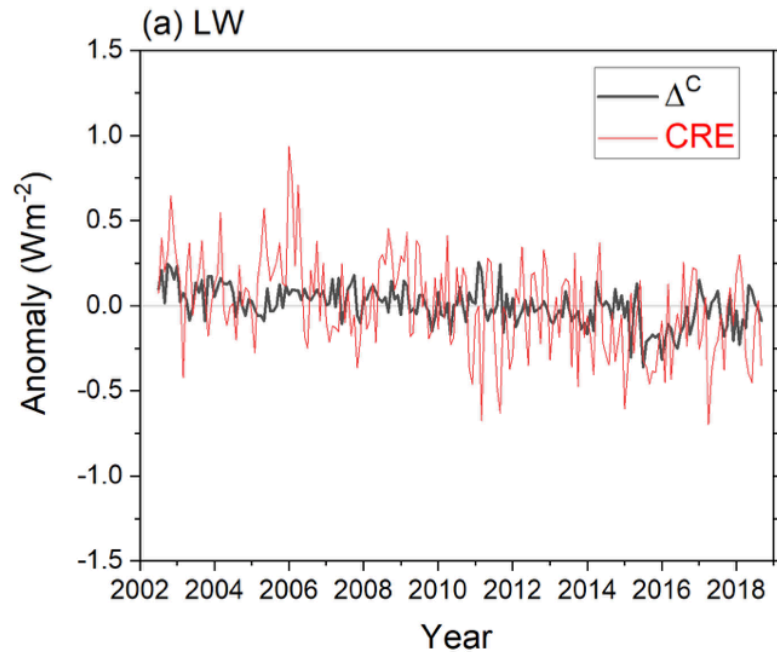
(d) $\Delta^c(\text{ERA5}) - \Delta^c(\text{SYN1deg})$

(Wm^{-2})



- Regional RMS difference $\sim 2 \text{ Wm}^{-2}$. (1 Wm^{-2} for non-Polar Oceans).
- Largest discrepancies over sea-ice and in heavily polluted land regions (e.g., China).

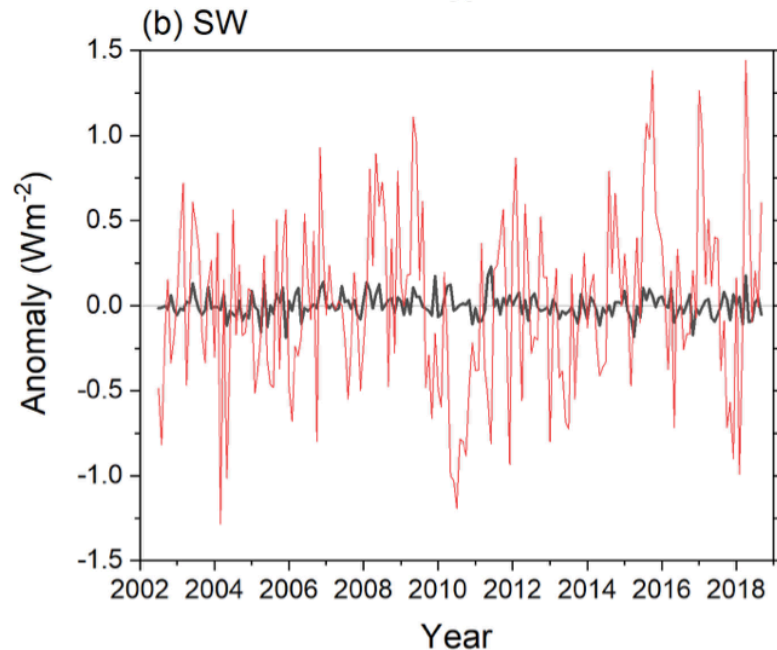
Anomalies in Global Mean Δ^c and CRE (07/2002-09/2018)



Standard Dev (Wm^{-2})

Δ^c : 0.11

CRE: 0.28



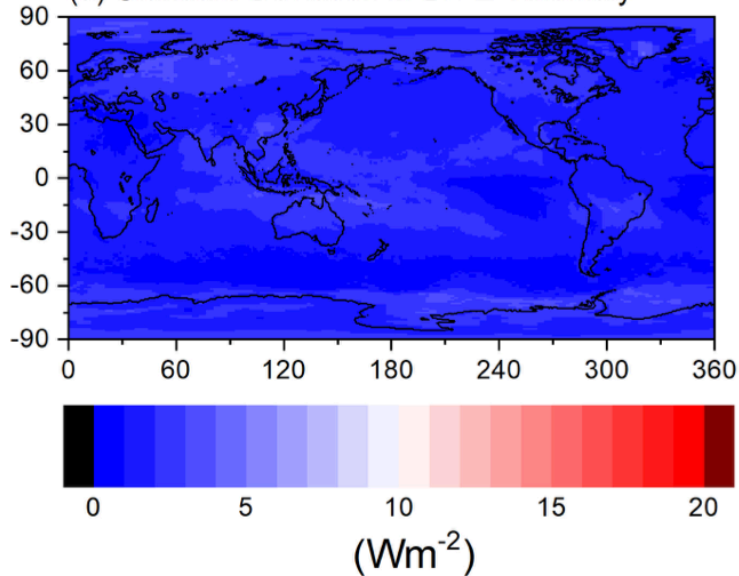
Δ^c : 0.069

CRE: 0.51

Standard Deviation in Regional Anomalies of Δ^c and CRE

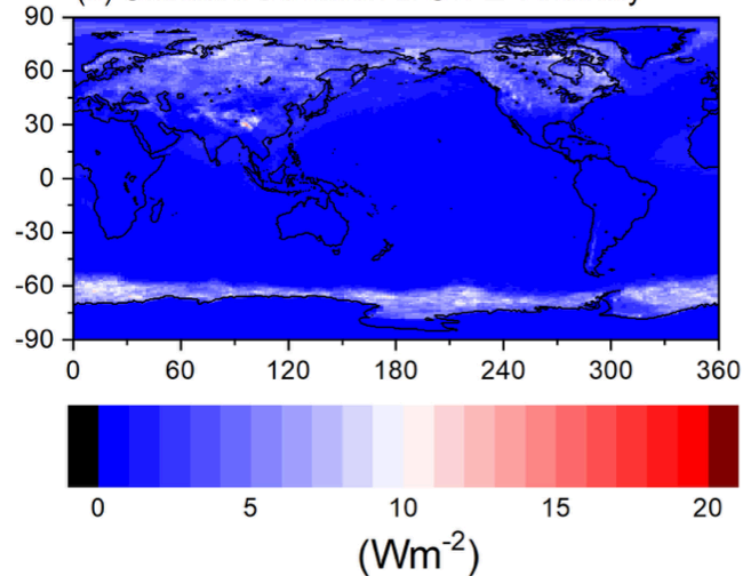
(a) Standard Deviation in LW Δ^c Anomaly

RMS
1.74



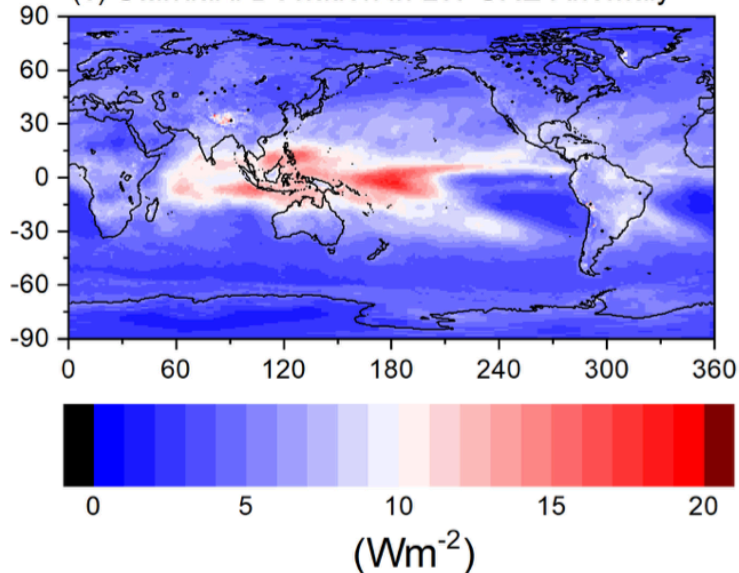
(b) Standard Deviation in SW Δ^c Anomaly

RMS
1.96



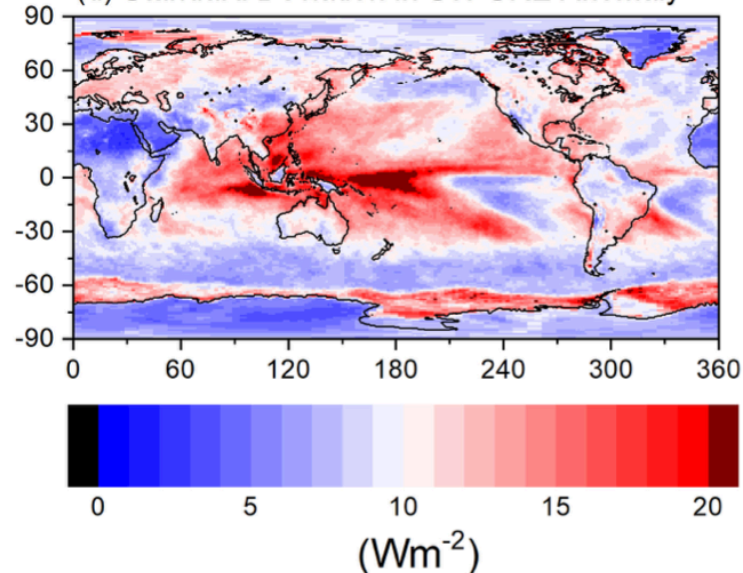
(c) Standard Deviation in LW CRE Anomaly

RMS
6.64



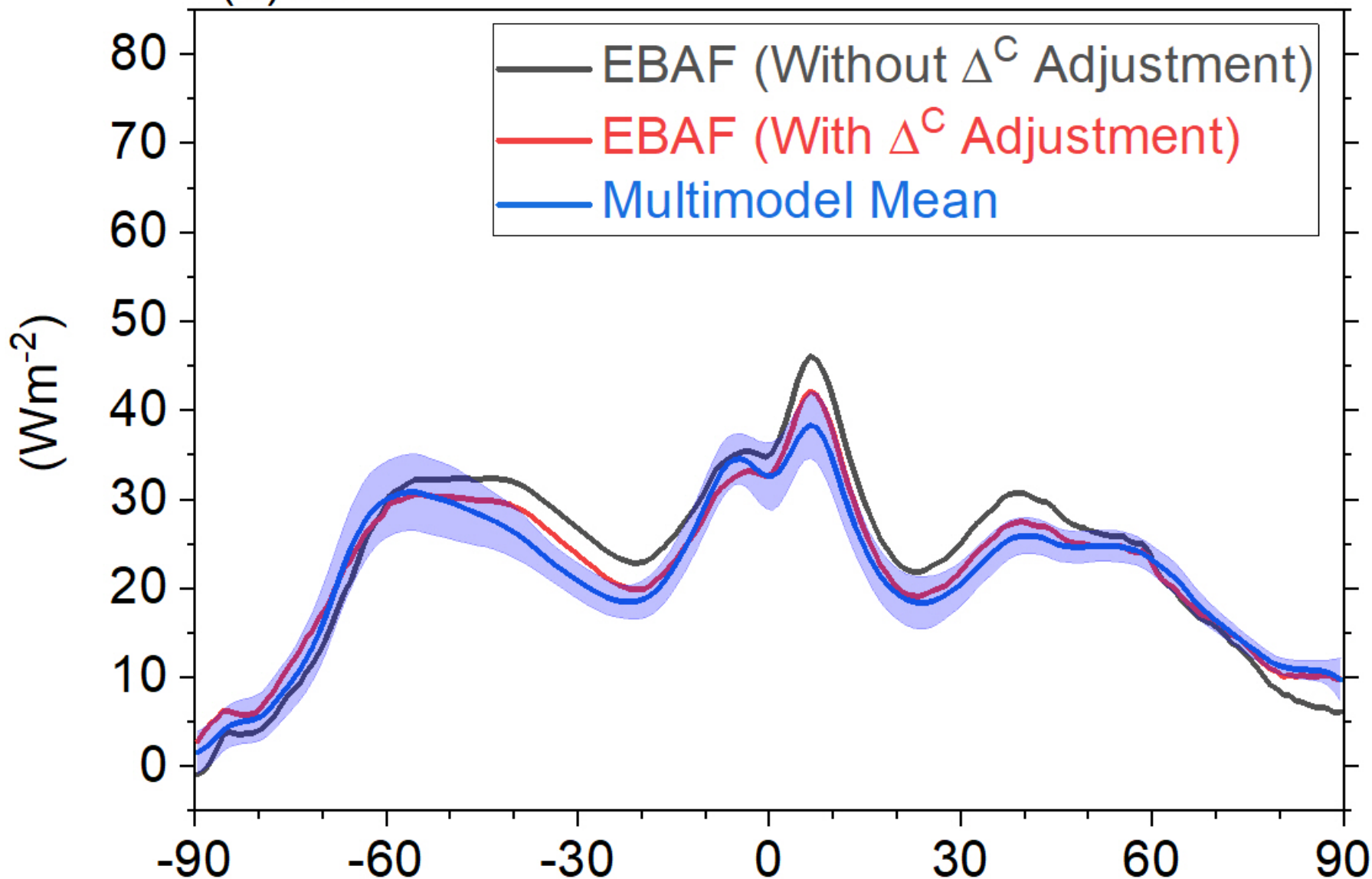
(d) Standard Deviation in SW CRE Anomaly

RMS
11.3



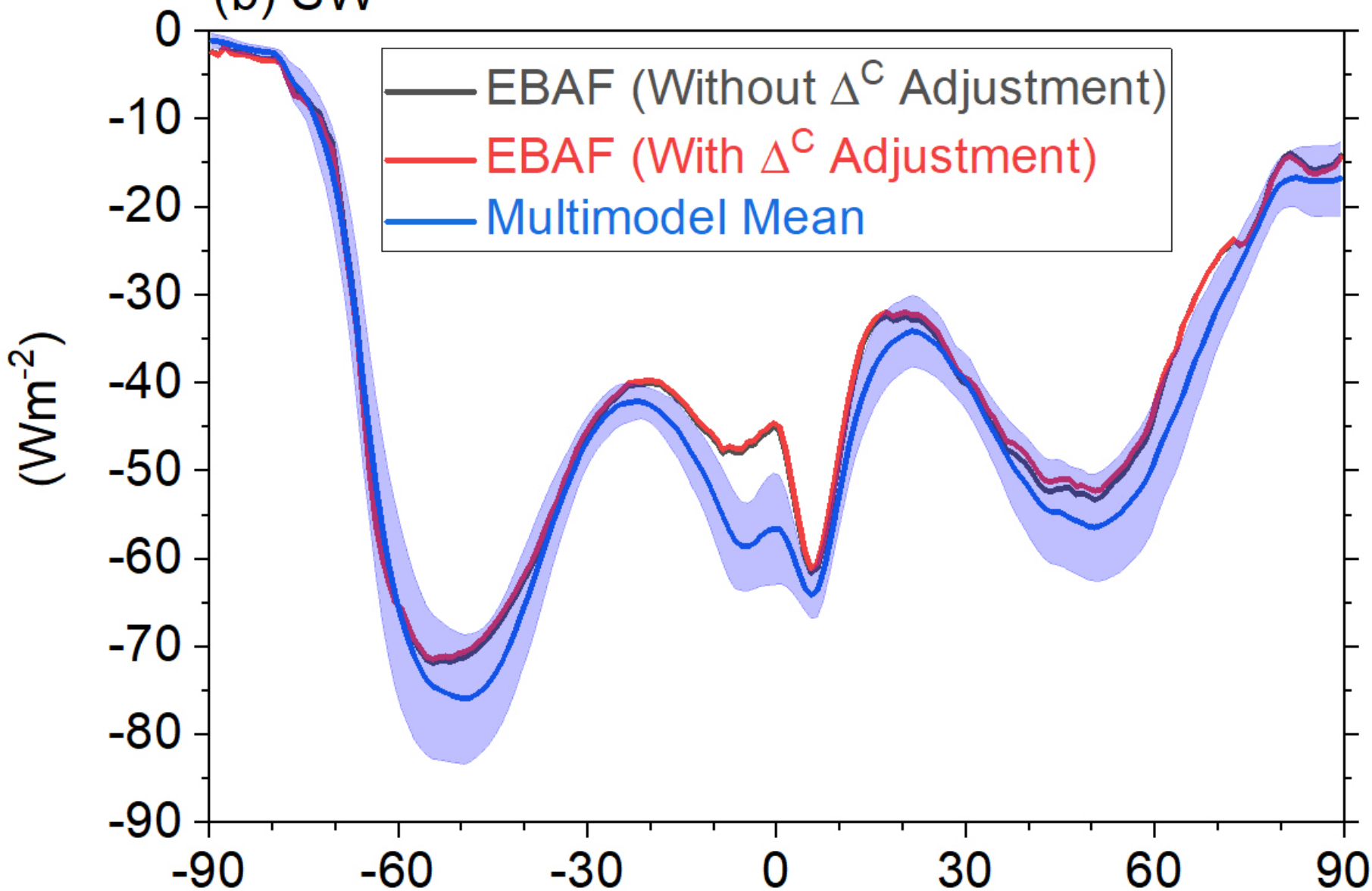
TOA Cloud Radiative Effect: CERES EBAF vs Multimodel Mean of 7 CMIP6 Models
(2003-2014; Shading: ± 1 Standard Deviation from the Multimodel Mean)

(a) LW

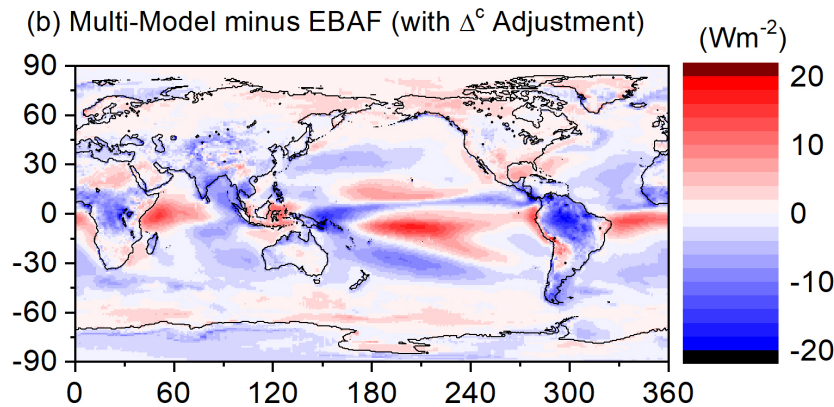
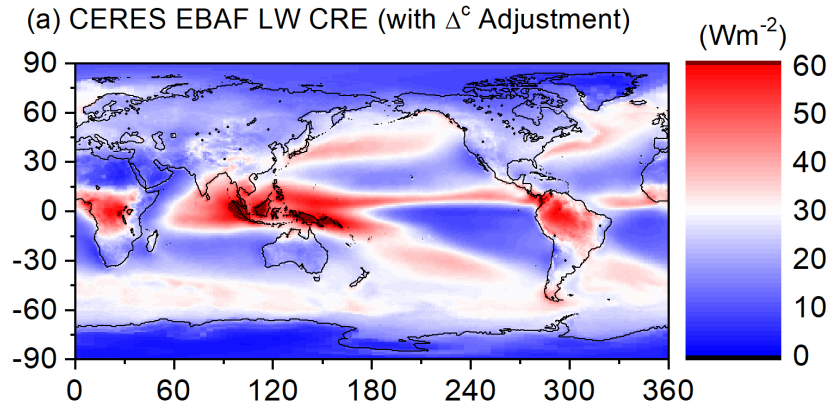


TOA Cloud Radiative Effect: CERES EBAF vs Multimodel Mean of 7 CMIP6 Models
(2003-2014; Shading: ± 1 Standard Deviation from the Multimodel Mean)

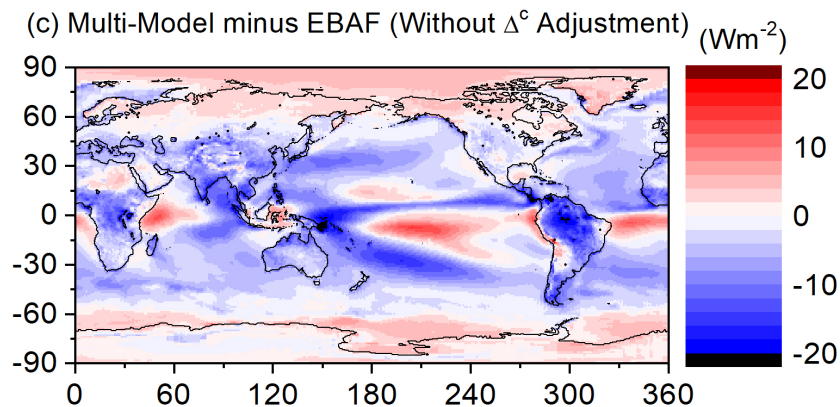
(b) SW



LW TOA Cloud Radiative Effect: CERES EBAF vs Multimodel Mean of 7 CMIP6 Models (2003-2014; Shading: ± 1 Standard Deviation from the Multimodel Mean)



RMS: 4.5 Wm^{-2}



RMS: 6.1 Wm^{-2}


Uncertainty in 1°×1° Regional Monthly TOA Fluxes and CREs

	TOA (Wm ⁻²)		
	All-Sky	Clear-Sky	CRE
SW	2.5	5.4	5.9
LW	2.5	4.6	4.5
NET	3.5	7.1	7.4

Changes to CERES EBAF Ordering Page



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EBAF Browse and Subset Products

Edition 4.1

EBAF Product	Parameters	Data Availability	Order Data
TOA Fluxes, Clouds	Observed TOA all-sky and clear-sky fluxes; CERES-MODIS cloud properties (Clear-sky for cloud free areas of $1^{\circ} \times 1^{\circ}$ region)	03/2000 - 12/2018	Browse & Subset
TOA & Surface Fluxes, Clouds	Observed TOA and computed surface all-sky and clear-sky fluxes; CERES-MODIS cloud properties (Clear-sky for total area of $1^{\circ} \times 1^{\circ}$ region)	03/2000 - 03/2018	Browse & Subset

Changes to CERES EBAF Ordering Page

Parameters

<input type="checkbox"/> TOA Fluxes 	<input type="checkbox"/> All Sky	<input type="checkbox"/> Clear Sky (for cloud-free areas of region)	<input type="checkbox"/> Clear Sky (for total region)
<input type="checkbox"/> TOA CRE Fluxes (clear-sky cloud removed) 	<input type="checkbox"/> Shortwave Flux 	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Solar Flux 	<input type="checkbox"/> Longwave Flux 	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Cloud Parameters 	<input type="checkbox"/> Net Flux 	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Surface Fluxes 	Click to select individual parameters		
<input type="checkbox"/> Surface CRE Fluxes (clear-sky cloud removed) 	Click to select individual parameters		

Summary

- Ed4.1 changes include:
 - New clear-sky fluxes & associated CREs. Clear-sky definition is more consistent with that used in climate models.
 - Reprocessed surface fluxes using consistent aerosols throughout (No changes made to TOA fluxes).
 - Reprocessed cloud properties from 03/2016 onwards (C6.1)
- Clear-sky adjustment reduces global mean clear-sky LW flux by 2.2 Wm^{-2} and increases SW flux by 0.5 Wm^{-2} . Larger regional changes.
- Global mean TOA CRE changes:

	EBAF Ed4.0	EBAF Ed4.1
LW	27.9	25.7
SW	-45.8	-45.3
Net	-17.9	-19.6

☐ Towards a Consistent Definition Between Satellite and Model Clear-Sky Radiative Fluxes

Norman G. Loeb, Fred G. Rose, Seiji Kato, David A. Rutan, Wenying Su, Hailan Wang, David R. Doelling, William L. Smith, and Andrew Gettelman

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Abstract  | PDF 

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